UNCERTAINTY OF PREDICTED HIGH Q^2 STRUCTURE FUNCTIONS DUE TO PARAMETRIZATION ASSUMPTIONS

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The HERA luminosity upgrade is expected to provide statistically significant measurements of the proton structure functions at $0.5<x<0.7$ and very high $Q^2(Q^2 >> M_Z^2)$. The behaviour of the parton densities (PDFs) in this high x, Q^2 regime is predicted from DGLAP evolution of PDF parametrizations from lower Q^2 fits of the data. Uncertainties in the PDFs at high x may propagate to lower x through DGLAP evolution at very high Q^2. In this presentation the behaviour of the PDFs at high x is reexamined. We present the effects at $Q^2 = 40000 GeV^2$ and compare our results with uncertainties obtained from propagation of experimental errors at high x, high Q^2 DIS data.

1 Introduction

The HERA and Tevatron upgrades will allow experiments to test the behaviour of PDFs at very high x and Q^2. Violations of the predicted PDF behaviour may signal new physics beyond the standard model. Thus, it is important to understand to what extent the predicted PDF behaviour depends on the parametrization assumptions. Currently there is no systematic study that estimates uncertainties due to parametrization assumptions.
In the past, a number of attempts to calculate PDF errors at high Q^2 was made. Recently [1], a large set of DIS data was fit and the error in DIS differential cross section was estimated as a function of x, Q^2 and y, taking into account all systematic and statistical errors. A conventional PDF parametrization was used: $xq(x) = N_q x^{A_q}(1-x)^{B_q}(1+C_q x)$. The quoted error on the neutral current (NC) DIS cross section $d\sigma^{NC}/dx$ at $x = 0.75$ is $\simeq 0.1$. Yang and Bodek [2] introduced a modification to the d/u ratio $(\frac{d}{u})' = \frac{d}{u} + 0.1x(x+1)$ which lead to better agreement with recent charged current data from HERA. Finally, Kuhlmann et al [3] added an extra term to the conventional up valence quark parametrization in order to investigate if such modifications could explain the reported HERA excess at high Q^2 in 1997. Such a term generates a significant excess for $x \geq 0.75$: $xu(x) = xu(x)_{CTEQ4} + 0.02(1-x)^{0.1}$. Their study showed that even large modifications at high x could not explain the HERA excesses. The quoted modification in F_2 at $x = 0.75$ and $Q^2 = 40000 GeV^2$ is: $\Delta F_2/F_2^{NC} < 0.3$. Although this study for the first time questioned the induced error in F_2 due to modifications to the PDFs, it did not cover the full

parameter space of possible modifications. Also, the extra term $0.02(1-x)^{0.1}$ is problematic as $x \rightarrow 0$ when the valence sum rule is calculated.

2 Systematic Modification of the PDFs at high x

In this section a new approach is presented. It was found that the simplest two-parameter modification (addition in our case) in the standard up quark density which produces sum rules free from infinities, is:

$$xu(x) = xu(x)_{CTEQ4} + Dx(1-x)^P \tag{1}$$

The extra term $Dx(1-x)^P$ diverges as $x \rightarrow 1$ for negative powers P. This extreme behaviour of the PDF can be regulated by adjusting the strength parameter P, so that it does not violate any experimental observations. In this study the Yang-Bodek correction is included: $xd(x)' = xd(x)_{CTEQ4} + 0.1x(x+1)xu(x)$. We fit DIS fixed target data for $x > 0.01$ and $W^2 > 10GeV^2$ (Datasets: NMC, BCDMS, SLAC, E665). QCDNUM [1] was used to evolve parametrizations. The available value space for the extra term is constrained by experimental data. Our goal is to find the region of the D,P parameter space that maximizes dF_2/F_2 at high Q^2. We constrain the D and P parameters: $\Delta(xu_v(x) + xd_v(x))/(xu + xd) \leq 0.2$ (Total momentum constraint), $\chi^2(x_{BCDMS} > 0.5)/dof \leq 3$. In figure 1 the allowed parameter space is shown. In figure 2 we pick up pairs of (P,D) points from the boundary of the param. space and calculate the effects of the corresponding extra term at very high Q^2. As shown, even extreme modifications of the structure functions at high x cannot produce more than 35% excess in F_2 because of the BCDMS data constraint. In figure 3 the chosen modified parametrizations are shown together with the BCDMS data and the CTEQ4 parametrization.

3 Conclusions

This study shows (in agreement with previous estimates) that even largely anomalous and unconventional behaviour of the PDFs at high x, produces effects comparable to statistical and systematic uncertainties, at the highest experimentally accessible x and Q^2 regimes. It seems unlikely that any fine tuning of the PDFs can produce a factor of two or higher excesses at high Q^2.

References

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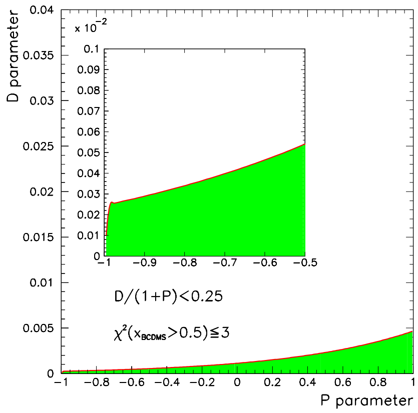

Figure 1: Allowed P,D parameter space.

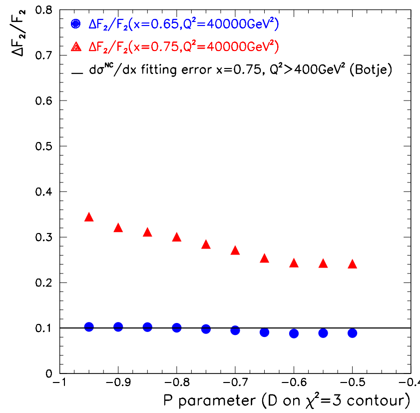

Figure 2: Modifications in F_2 for D and P values at the boundary of the parameter space.

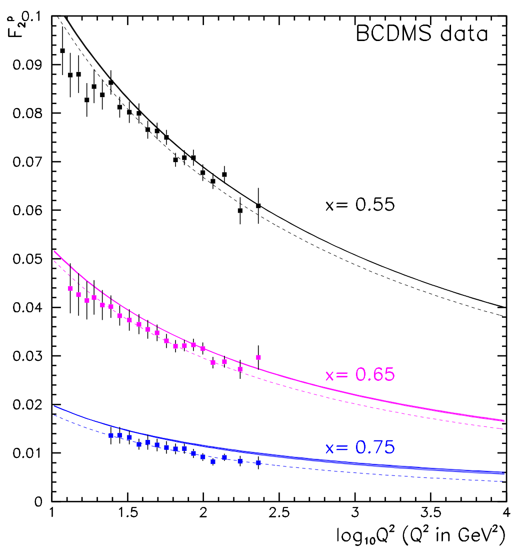

Figure 3: Comparison between modified F_2 distributions and BCDMS data.